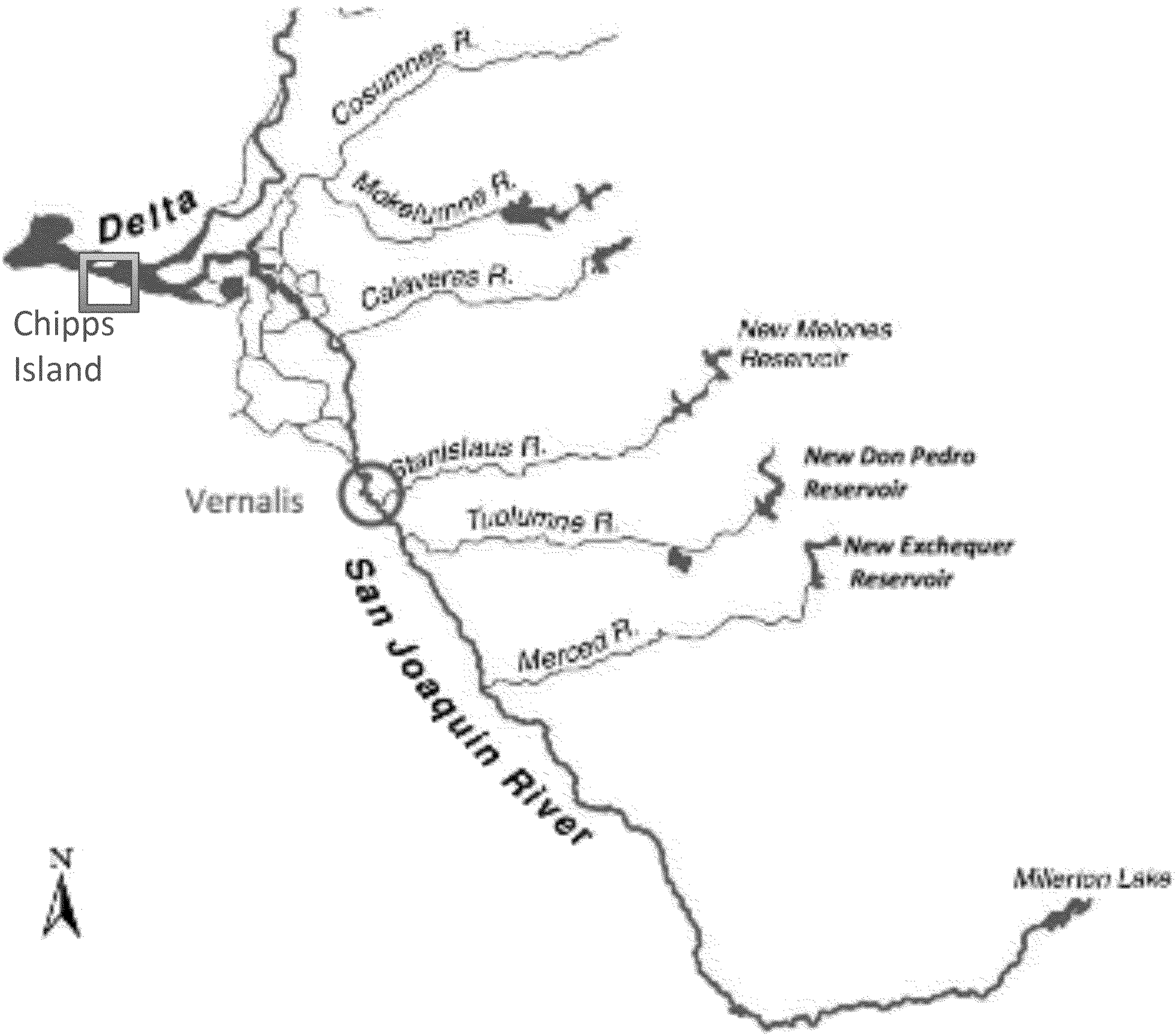
San Joaquin Salmon:
Setting Draft Objectives



Draft by
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The Bay Institute

Key Points

- San Joaquin Chinook: declining **rapidly**
- Viable or "healthy" salmon populations display acceptable levels of each of the four attributes of viability (NMFS 2000)
- SMART Objectives (bio-criteria) for these attributes of viability are needed to restore San Joaquin salmon using Adaptive Management
- Data needed to set such planning targets are available
- Bio-criteria for the tributaries/mainstem SJR should reflect anticipated improvements in the Delta (& vice-versa)
- Targets discussed previously may not be adequate to restore populations to healthy condition

Context for Setting Target Bio-Criteria for San Joaquin Chinook salmon

Previous Narrative Goals:

- "...support and maintain the natural production of viable native San Joaquin River watershed fish populations migrating through the Delta … Indicators of viability include abundance, spatial extent or distribution, genetic and life history diversity, migratory pathways, and productivity" (Previous Draft SED; emphasis added)

- "...achieve a doubling of natural production of chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law.” (2006, Water Quality Control Plan, emphasis added)

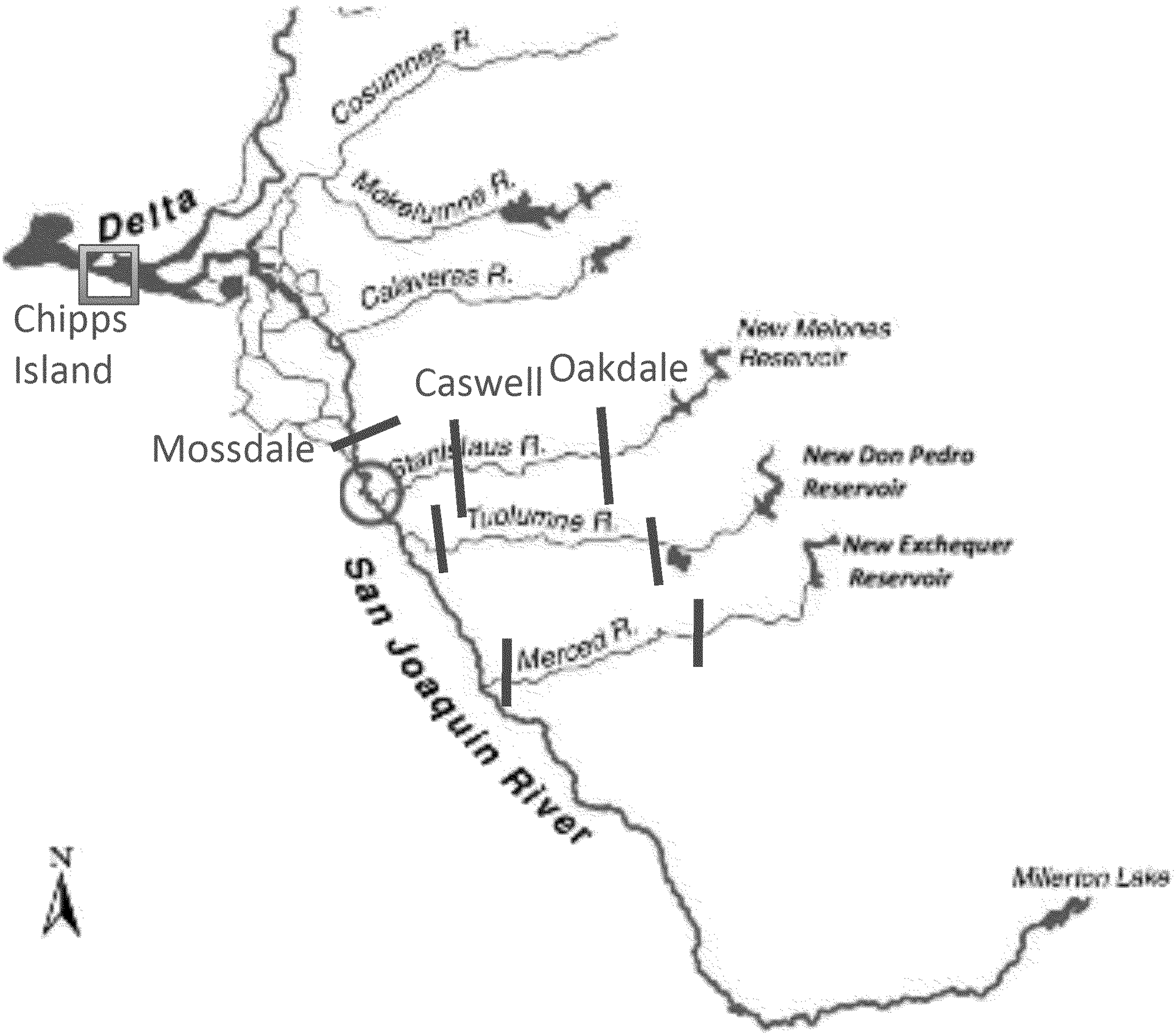
Beneficial Uses:

- Commercial and Sport Fishing (**COMM**), Cold Freshwater Habitat (**COLD**), Migration of Aquatic Organisms (**MIGR**), Spawning, Reproduction, and/or Early Development (**SPWN**), Estuarine Habitat (**EST**), Wildlife Habitat (**WILD**) - Rare, Threatened, or Endangered Species (**RARE**)

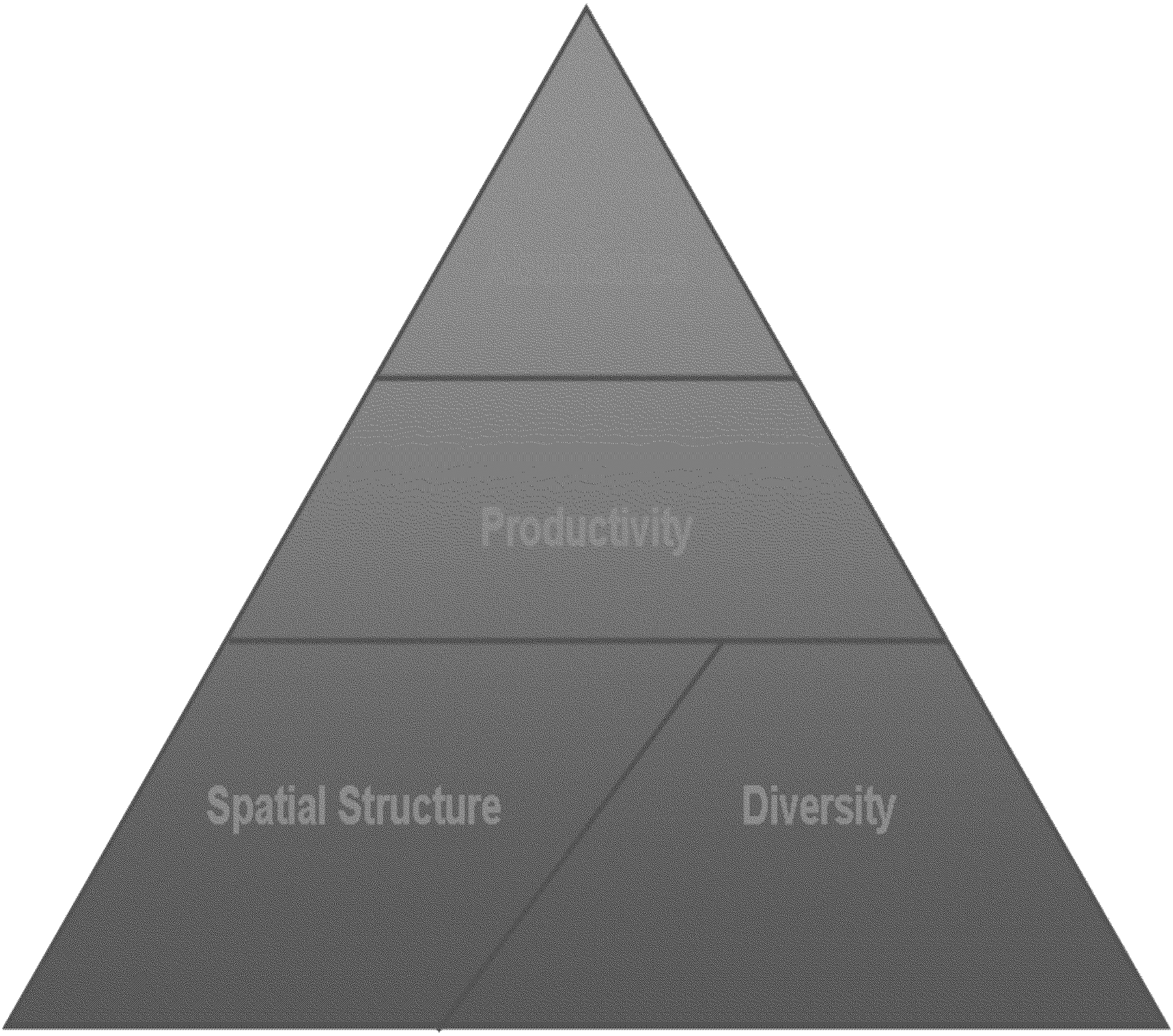
Bio-criteria (objectives) are SMART

- Specific
- Measureable
- Achievable
- Relevant to a GOAL
- Time-Bound

Abundance, productivity, and life history timing through the San Joaquin Valley and Delta are <u>*Measureable*</u>



Salmon Population Viability



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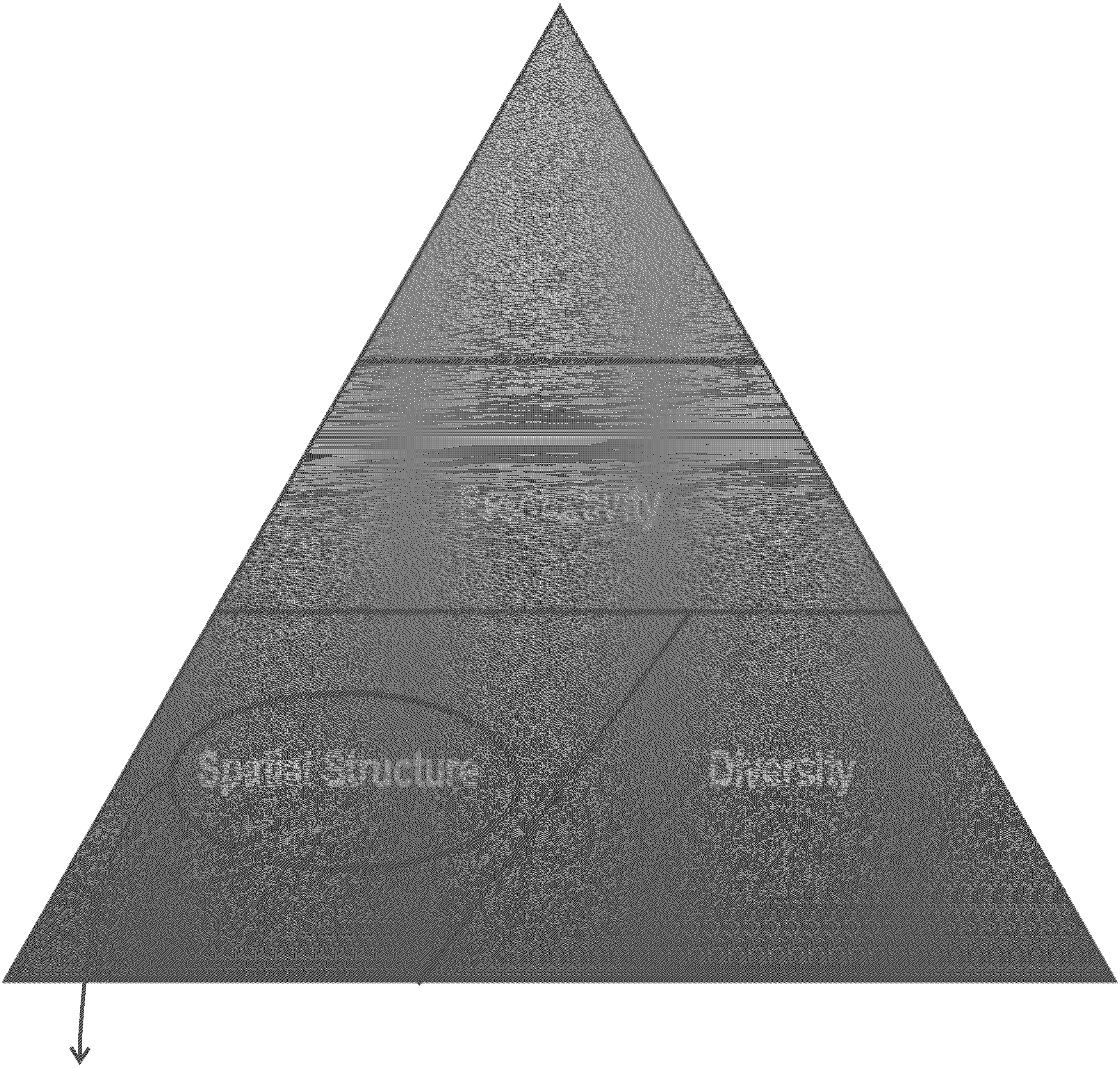
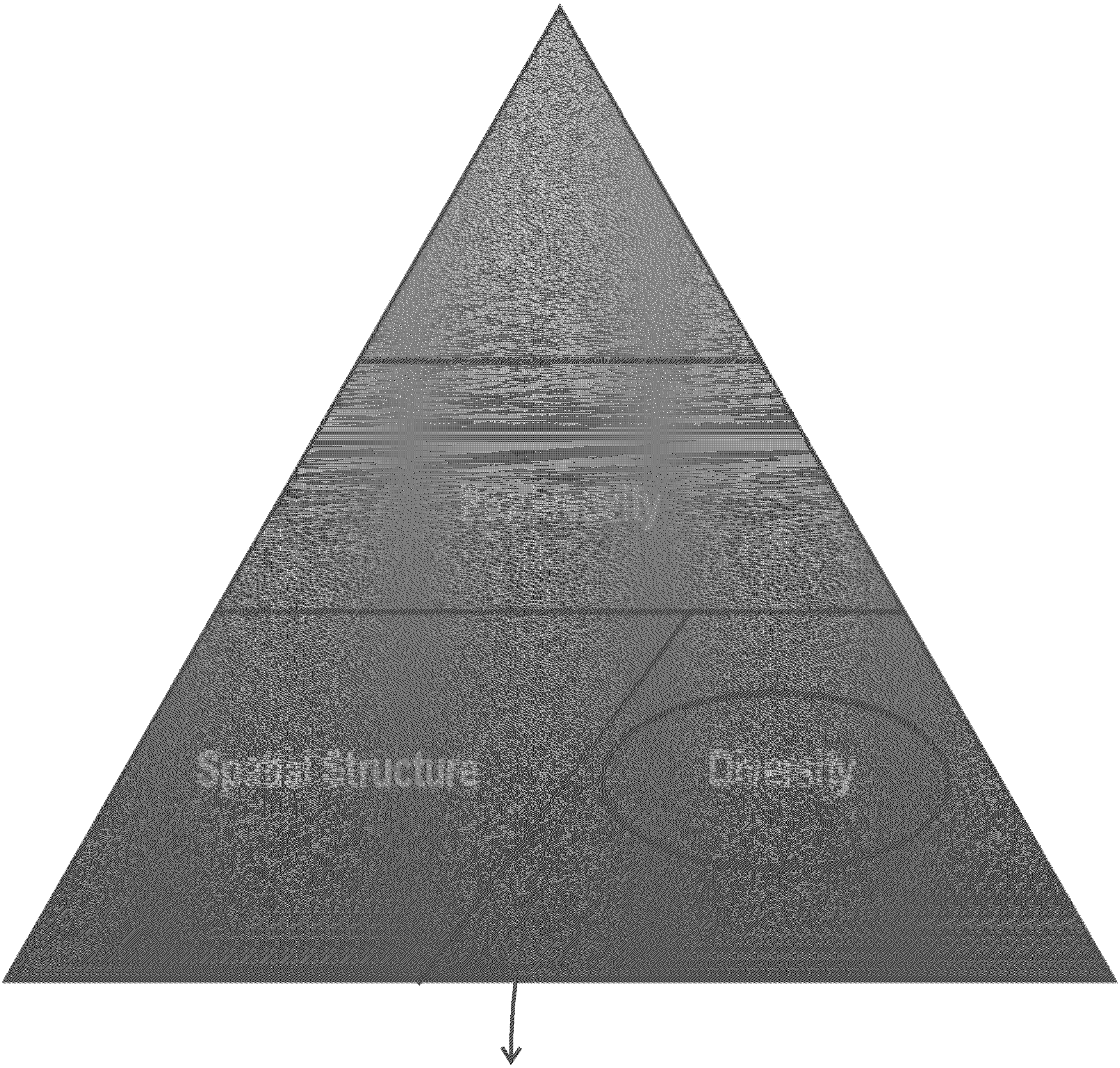


Restoration of Chinook salmon populations in San Joaquin tributaries ***IS*** restoration of spatial structure for this species

Salmon Population Viability



Restoration and maintenance of Life History Diversity is essential to maintain population resilience in unpredictable environments

Life History Objectives
Timing*size as proxy

Run	Migration	Peak migration	Spawning period: Total	Spawning period: Peak	Juvenile emergence	Juvenile stream residency (months)	Smolt out-migration
Sacramento River basin							
Late-fall	Oct–Apr	Dec	Early Jan–Apr	Feb–Mar	Apr–Jun	7–13	Nov–May
Winter	Dec–Jul	Mar	Late Apr–early Aug	May–Jun	Jul–Oct	5–10	Nov–May
Spring	Mar–Sep	May–Jun	Late Aug–Oct	mid-Sep	Nov–Mar	3–15	Mar–Jun and Nov–Apr
Fall	Jun–Dec	Sep–Oct	Late Sep–Dec	Oct–Nov	Dec–Mar	1–7[a]	Mar–Jul
San Joaquin River basin (Tuolumne River)							
Fall[b]	Oct–early Jan	Nov	Late Oct–Jan	Nov	Dec–Apr	1–5[a]	Mar–Jun

[a] At high streamflows, an unknown proportion of fry may emigrate downstream within a few weeks of emergence to rear in the Sacramento–San Joaquin Delta (Rutter 1904a; Kjelson et al. 1982; USFWS 1995; FERC 1996). A small fraction of fall-run juveniles (roughly, <5% of the total number) remain in freshwater for over one summer and emigrate as yearling smolts in the following Nov–Apr period (USFWS 1995).

[b] In the San Joaquin River basin, spawning migration and spawning in the tributaries may occur later than in the Sacramento River basin, depending on streamflow conditions (T. J. Ford, Turlock and Modesto Irrigation districts, personal communication). The Tuolumne River fall-run exemplifies a naturally sustained population in the San Joaquin River basin (based on FERC 1996; Ford, unpublished data).

From Yoshiyama, Fisher, and Moyle. 1998

High variation in timing of migration indicates the importance of diversity to the population

Size at Migration

Documented Across a Range of Years
(Ex: Caswell Rotary Screw Trap)

	Metric	1998 (wet)	2002 (dry)
Fry <55 mm	N	1,614,766	4,202
	Proportion	87%	4%
	Range	112	72
	Interval	Jan 8– Apr 29	Jan 16– Mar 28
	25-75% Range	Feb 6 – Feb 16	Feb 19 – Feb 28
	Median	42	55
Parr 55mm> x <75mm	N	98,475	23,656
	Proportion	5%	23%
	Range	100	113
	Interval	Feb 17– May 27	Feb 14 – Jun 6
	25-75% Range	Mar 25– Apr 8	Apr 16 – May 4
	Median	91	116
Smolt >75mm	N	138,017	76527
	Proportion	7%	73%
	Range	123	99
	Interval	Mar 6 – Jul 6	Mar 1 – Jun 7
	25-75% Range	Apr 28 – May 23	Apr 26 – May 13
	Median	133	122

Life History Objectives

Goal: Support the fullest expression of fall run Chinook salmon life history diversity in order to increase population stability, resilience, and productivity.

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***<u>Objective #1</u>*: (Life History – Timing of Migration)**

By year 10, in every year, migration of fall run Chinook salmon will be detected in every week* between:

	Caswell RST		Mossdale** Trawl	
Size	Start Week	End Week	Start Week	End Week
Fry (<55mm)	Last of January	2nd of April	***	***
Parr (55mm>x<75mm)	1st of February	Last of May	2nd of February	1st of June
Smolt (>75mm)	2nd of February	1st of June	3rd of February	2nd of June

* Until mean daily temperature at Mossdale ≥ 25°C.

** Tributary contribution can be assigned (e.g. by otolith analyses)

*** Mossdale Trawl does not reliably detect fish <55mm.

Life History Objectives

Goal: Support the fullest expression of fall run Chinook salmon life history diversity in order to increase population stability, resilience, and productivity.

<u>Objective #2</u>**: (Life History -- Size at Migration)**

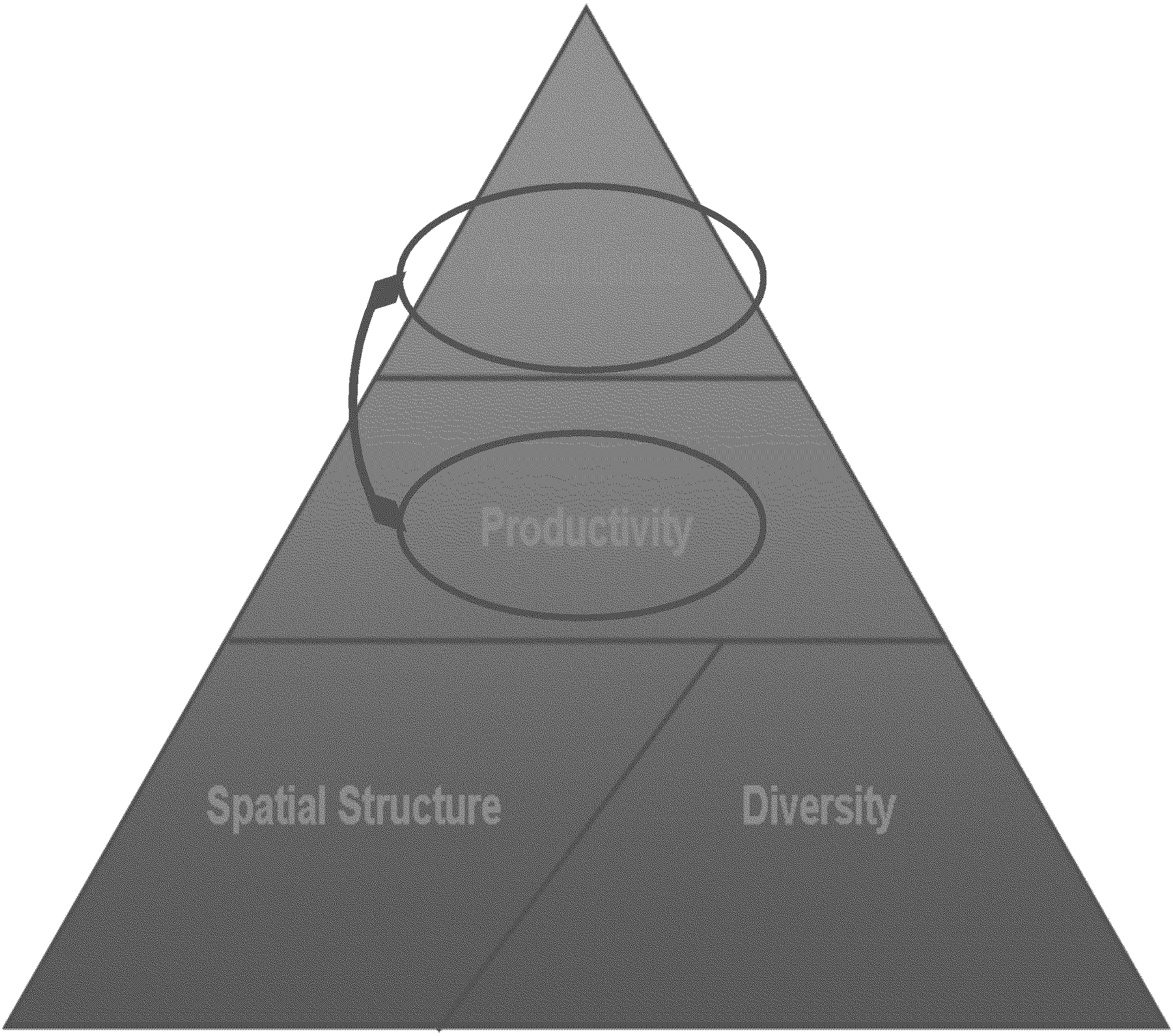
By year 12, generate annual emigrant size-class distribution as measured at Caswell RST as follows:

Size Class	Wetter Years	Drier Years
Fry (<55mm)	20% min	20% min
Parr (55>x<75mm)	20% min	30% min
Smolt* (>75mm)	10% min	20% min

Initial estimates of size class distribution & relative success based on work by Rachel Barnett-Johnson, Anna Sturrock, & others *in review*

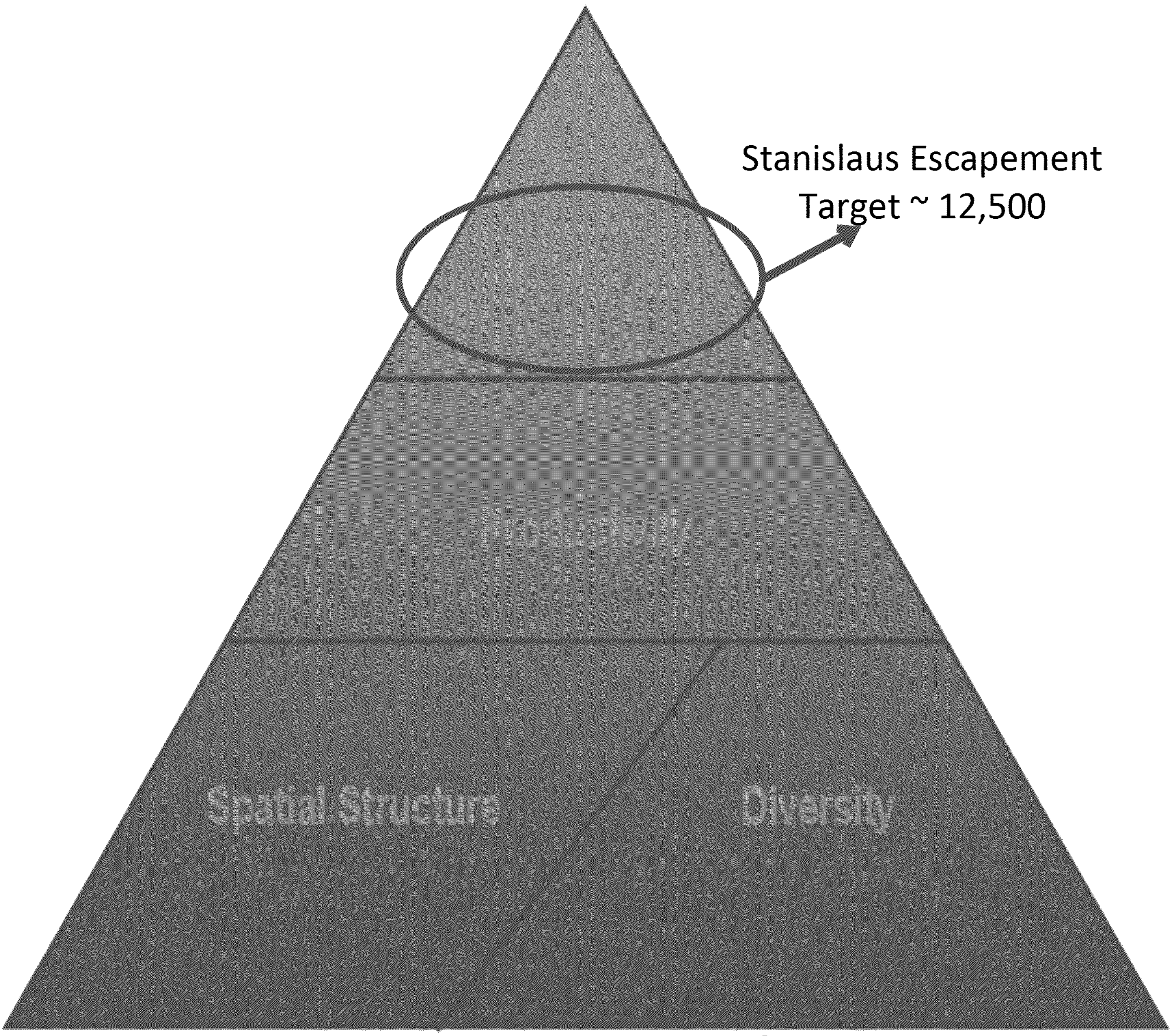
*Includes only juveniles that migrate before daily mean temperatures >25°C at Mossdale

Salmon Population Viability



Abundance and Productivity (population growth rate) are tightly linked – but they are **not** identical

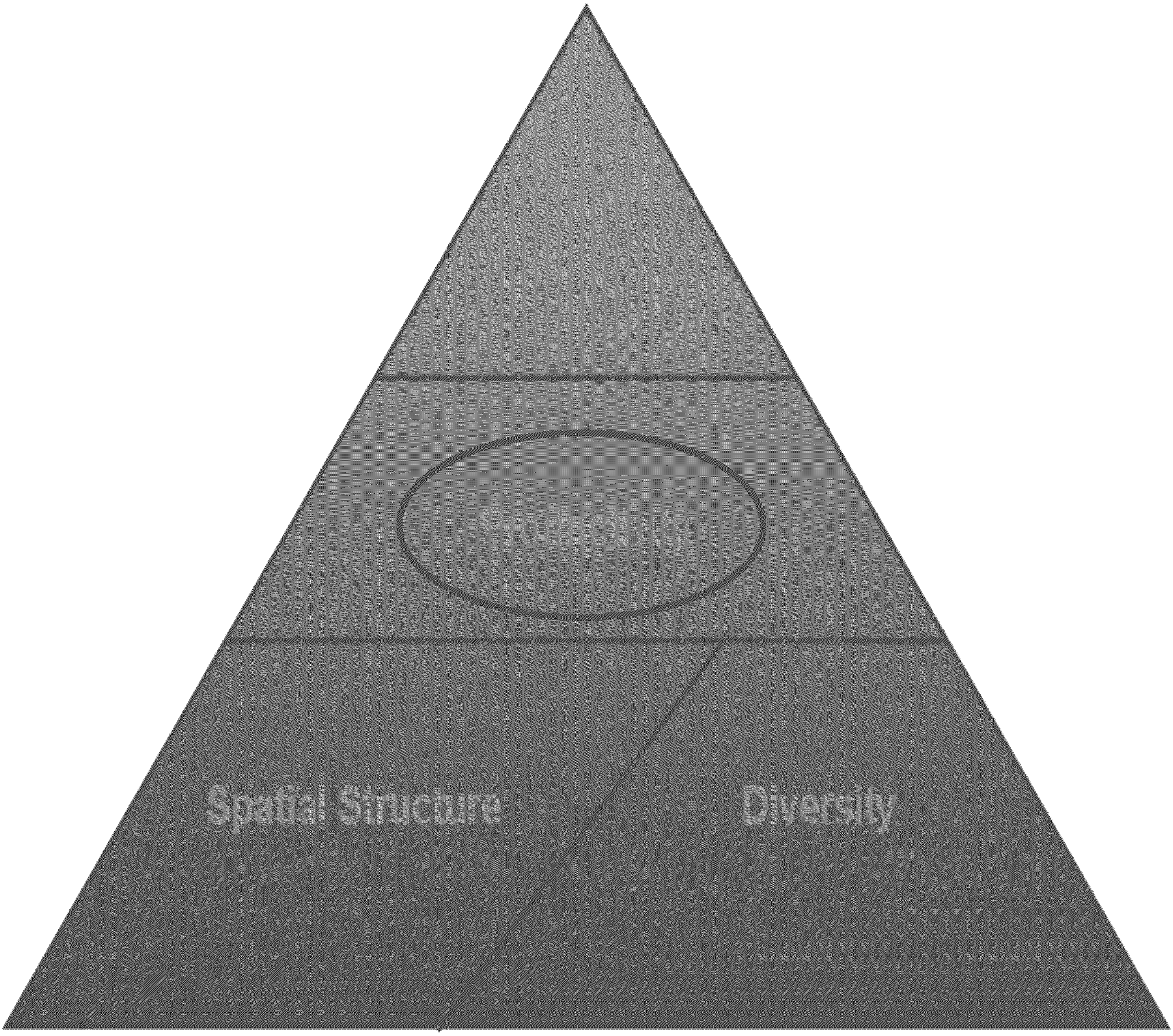
Salmon Population Viability



Abundance – Static targets may be defined by carrying capacity, ability to protect genetic diversity (PVA), harvest targets, etc.

In this case, abundance target is defined by CVPIA/AFRP doubling targets

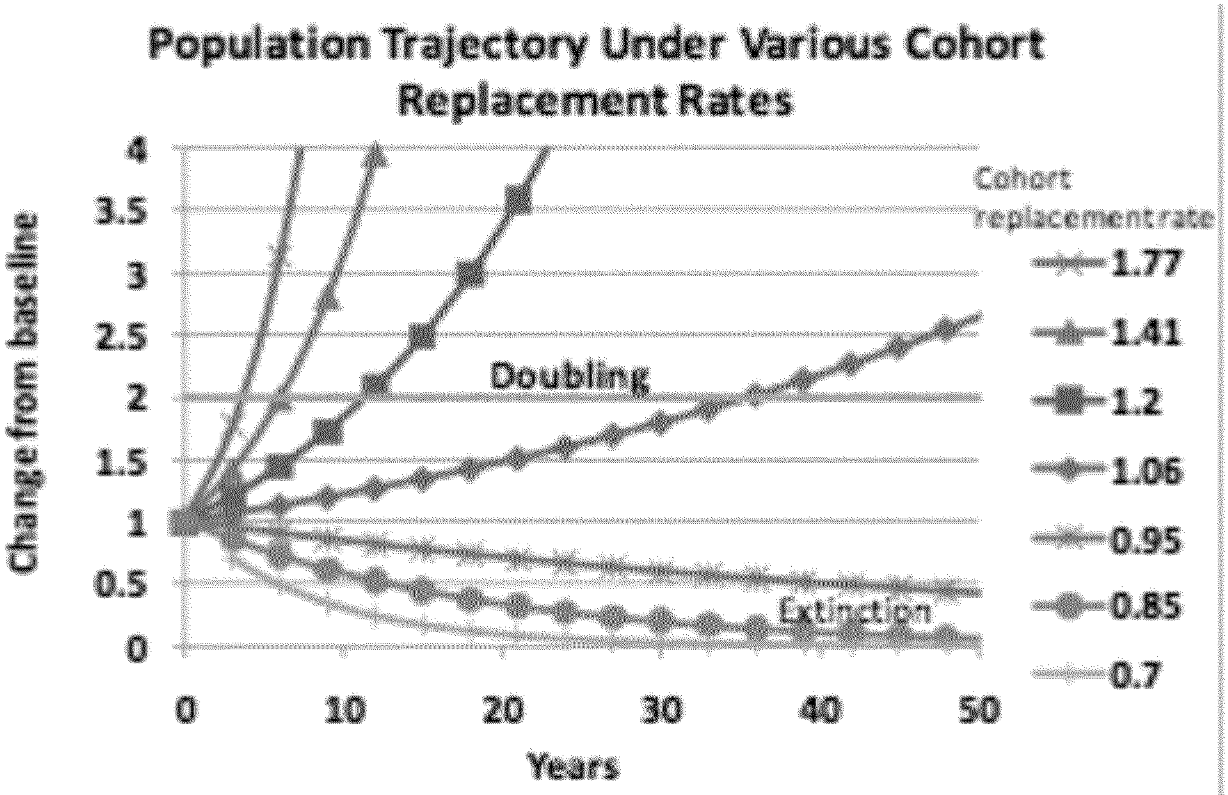
Salmon Population Viability



Productivity (population growth rate or survival in freshwater) = key measure of population "health"

Productivity
(Population Growth)

Often determined as a function of abundance target and time window to attain abundance target



From: US DOI. 2011. Testimony to SWRCB. February 8, 2011

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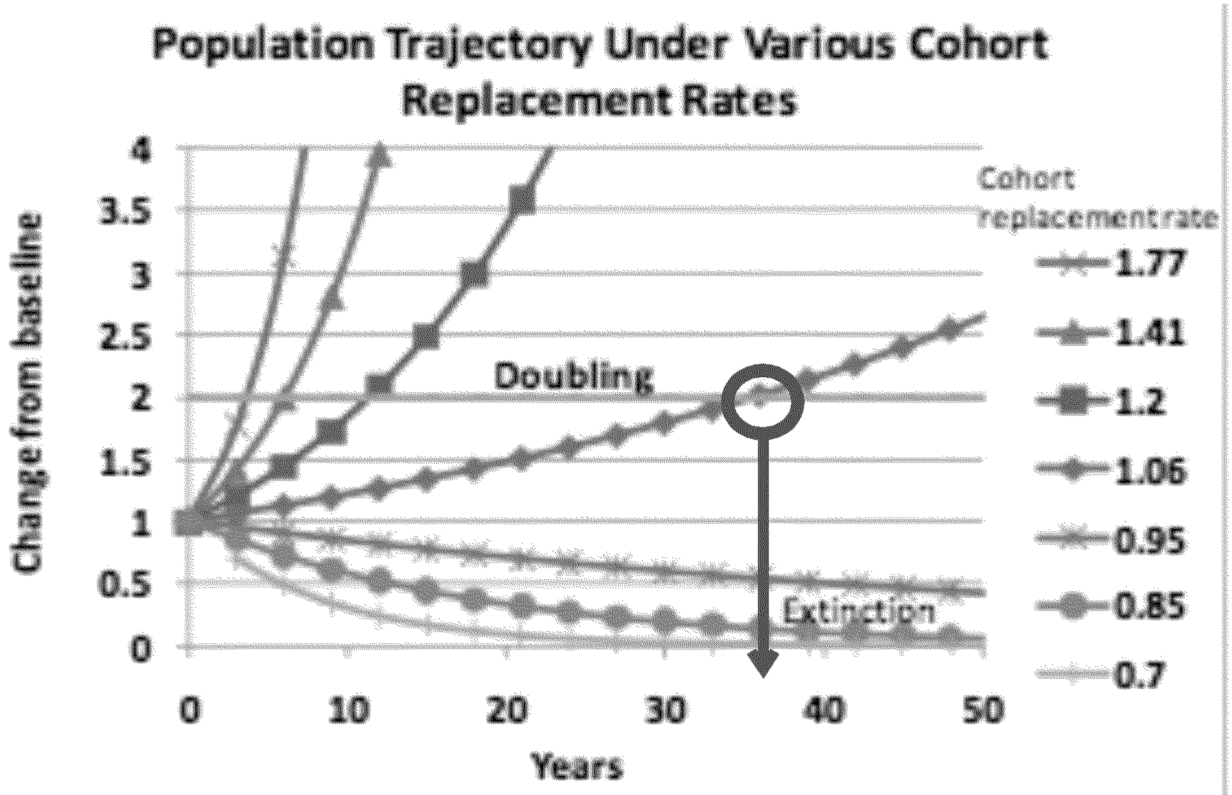

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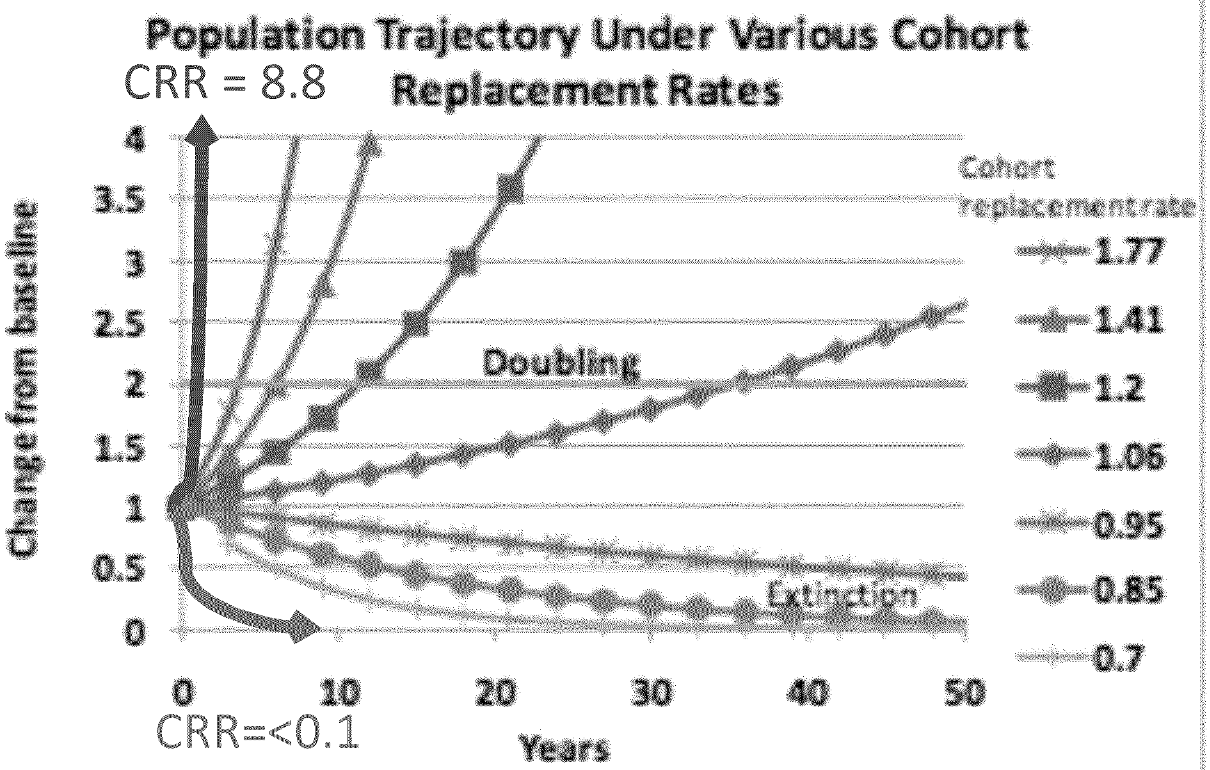


But,

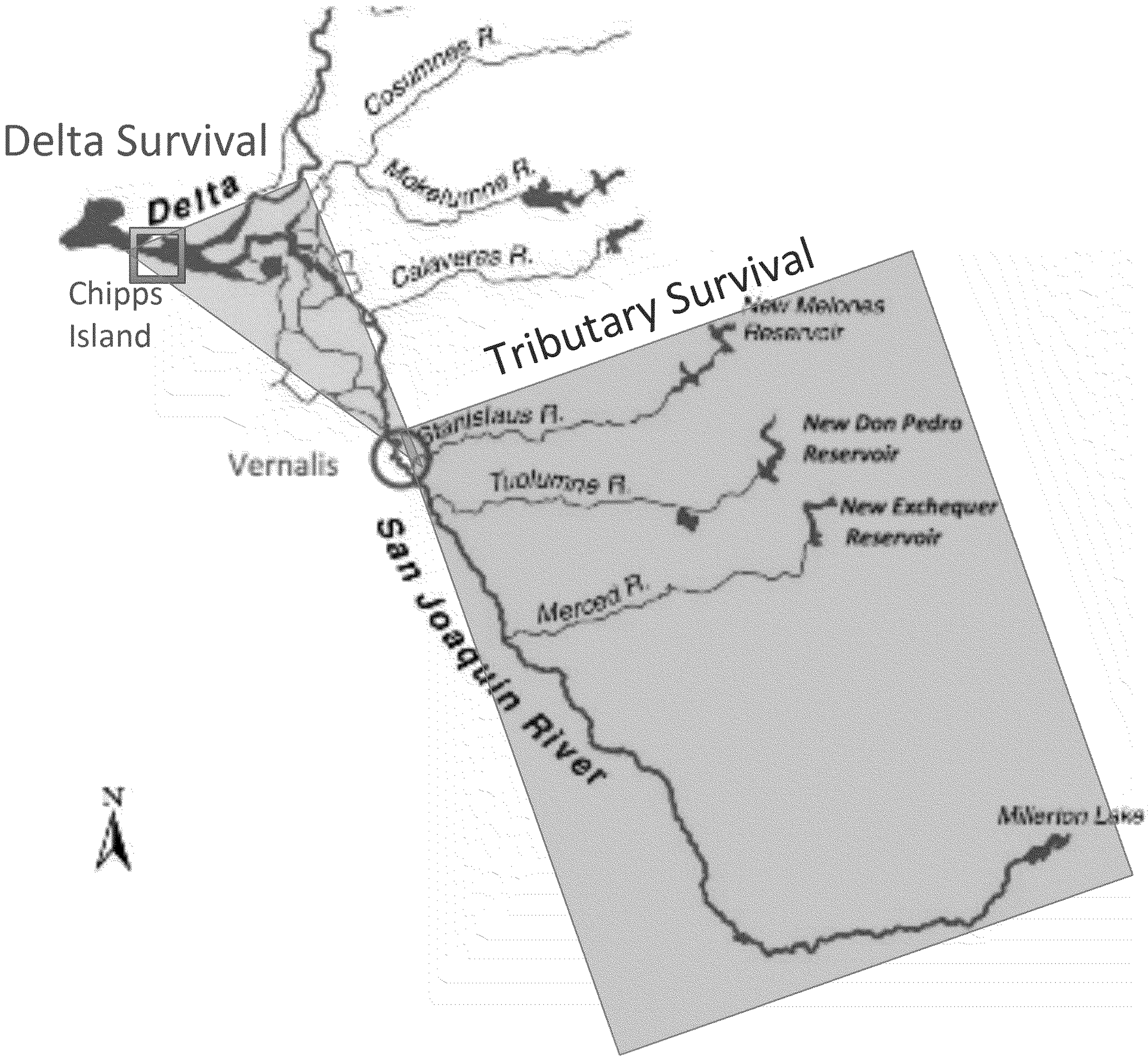
- Population growth rates are an *intrinsic* characteristic (“*r*”) and an indicator of population viability, health, and resilience in their own right
- Typical population growth rates for Chinook salmon are **much** higher than those suggested by the “time-to-attain-doubling” approach

Abundance – Productivity Bio-Criteria

Relevant Goals

- Attain production doubling targets
  (3 generations; 9 years)
  - No single process is responsible for attaining adult production
  - All processes must set objectives that are consistent with attainment
- Increase population resilience
  (2 more generations; 15 years)
  - Population can rebound from low recruitment to attain doubling targets
- Establish healthy, self-sustaining populations
  (3 more generations; 24 years)
  - Population growth rates resemble those typical of the species

Freshwater Survival = Tributary Survival x Delta Survival



Survival Specifics

Previous Efforts to Estimate Juvenile Survival Produced Slightly Different Estimates

Survival	**USFWS (2011)**	**NMFS (2012)**	**Stanislaus (2013)**	**Combined Estimate**
In-river	6.64%	5.64%	2.20%	2.20%
River-to delta	53.53%**		53.53%**	53.53%
In-delta	5%	5%	1.50%	5%
To production	2.83%	2.83%		2.83%
Post-production	50%	70%	57%	57%
Freshwater Survival	0.18%	0.28%	N/A	0.06%
SaltWater Survival	1.42%	1.98%	N/A	1.61%
Implied CRR	0.06	0.14	0.10	0.02

**Captures survival from last tributary sampling to beginning of "delta". Inserted because it appeared not to have been incorproprated into original estimates

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2008 BiOp

Sonic Tagging

RST Data & ChinookProd

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Survival in some reaches not estimated by previous work:

- Survival from lowest trap station to Delta (San Joaquin River survival)

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Post-production	50%	70%	57%	57%
Freshwater Survival	0.18%	0.28%	N/A	0.06%
Implied CRR	0.06	0.14	0.10	0.02
Typical Freshwater Survival	8.6% (Bradford 1995) 10.1% (Quinn 2005) 12.4% (Healey 1991)			

In general, survivals and resulting CRR are extremely low & **not sustainable**

Abundance Goal
Attain Production Doubling Targets in 3 Generations (CRR = 1.71)

- Freshwater (Egg-Smolt) survival necessary to grow population at this rate *varies depending on assumed ocean/fishery mortality*

	USFWS	NMFS	Combined
Ocean Survival	50%	70%	57%
Implied FW Survival	4.835%	3.455%	4.24%

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Attain Production Doubling Targets in 3 Generations (CRR = 1.71)

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	USFWS	NMFS	Combined
Ocean Survival	50%	70%	57%
Implied FW Survival	4.835%	3.455%	4.24%
Necessary in Tributary if **Delta = status quo**	**97%**	**69%**	**85%**

- Attainment w/o Delta improvement = unlikely
- Attainment w/o tributary improvement = impossible

Abundance – Productivity Bio-Criteria

How to allocate freshwater survival improvements between Delta & upstream

Attain 4.84% (USFWS)	Even Split	Pro Rata (per RM)	Equal Improvement
Upstream	22%	24.28%	18.40%
Delta	22%	19.91%	25.91%

Abundance – Productivity Bio-Criteria

How to allocate freshwater survival improvements between Delta & upstream?

Attain 4.84% (USFWS)	Even Split	Pro Rata (per RM)	Equal Improvement
Upstream	22%	24.28%	18.40%
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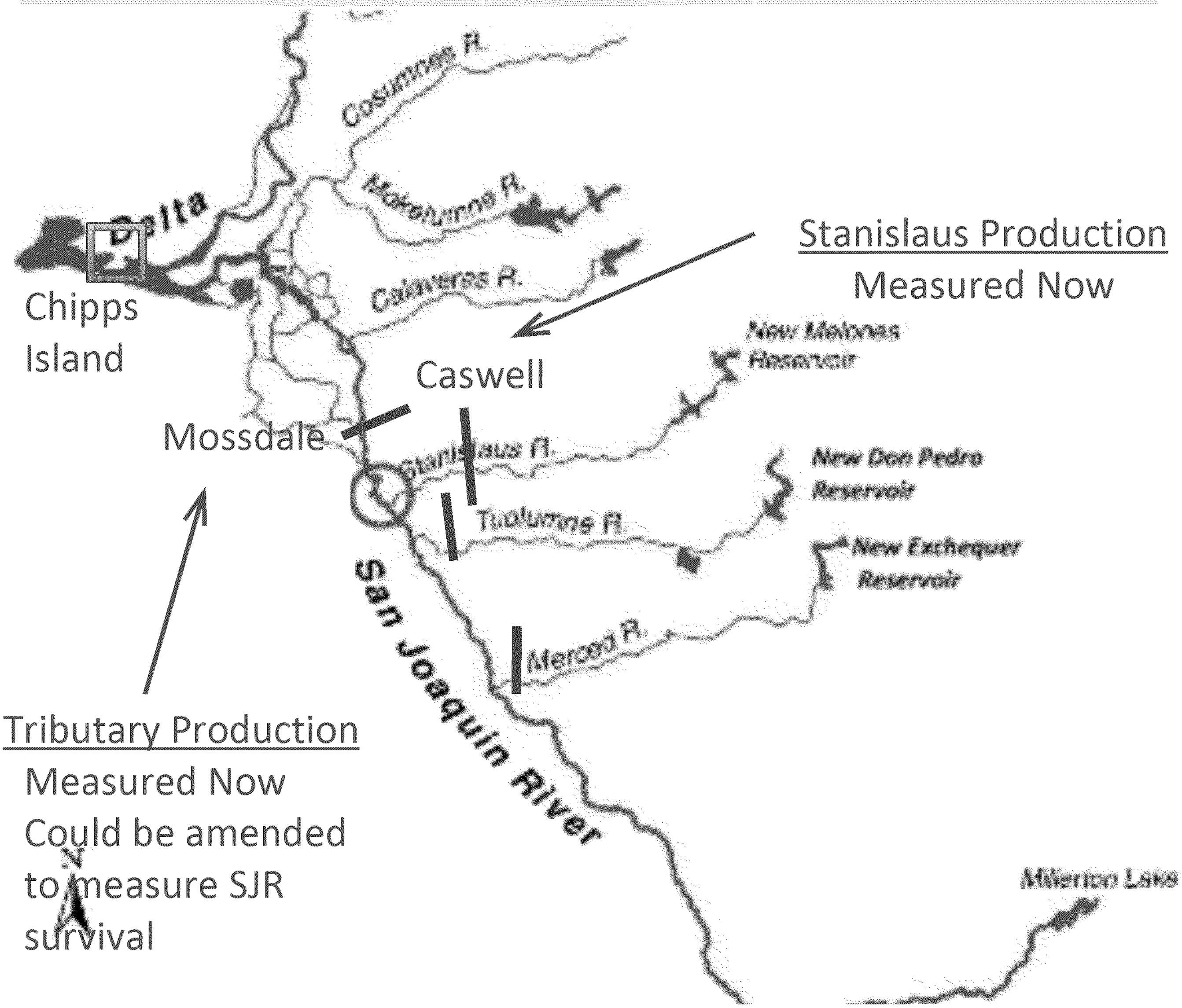

<u>Stanislaus Production</u>
Measured Now

<u>Tributary Production</u>
- Measured Now
- Could be amended to measure SJR survival

Abundance Goal

Attain Production Doubling Targets in 3 Generations

***Objective #3a*: (Abundance/Survival – CRR=1.71)**

By **year 9:**

a) the following minimum juvenile production successfully migrating past Caswell RST relative to WY type and spawner stock (previous fall escapement) will be exceeded

Production at Caswell needed to Attain Abundance Target Assuming proportionate improvement in pre-Delta & Delta survival			
Unimpaired Year Type	**Dry**	**Medium**	**Wet**
Egg-CRST Survival →	6%	13.31%	20.6%
Spawning Stock			
2,000	300K	665.5K	1.03M
4,000	600K	1.331M	2.06M
6,000	900K	2M	3.09M
8,000	1.2M	2.662M	4.12M
Basis: 1:1 spawner sex ratio; 5000 eggs/female; ~75% Caswell-Vernalis survival			

And

***b*) Survival from Caswell-Mossdale ≥ 46%**
(pro-rata estimate of through-Delta survival)

Productivity Goal
Population Resilient to Low Escapement

Objective #3b**: (Population Resilience – CRR=2.51)**

By **year 15:**

a) the following minimum juvenile production successfully migrating past Caswell RST relative to WY type and spawner stock (previous fall escapement) will be exceeded

Production at Caswell needed to Attain Abundance Target Assuming proportionate improvement in pre-Delta & Delta survival			
Unimpaired Year Type	**Dry**	**Medium**	**Wet**
Egg-CRST Survival →	9%	15.6%	22.2%
Spawning Stock			
2,000	450K	778.5K	1.1M
4,000	900K	1.557M	2.2M
6,000	1.35M	2.335M	3.3M
8,000	1.8M	3.114M	4.4M
Basis: 1:1 spawner sex ratio; 5000 eggs/female; ~78% Caswell-Vernalis survival			

And

b**)** Survival from Caswell-Mossdale ≥ 50.5% (pro-rata estimate of through-Delta survival)

Growth Rate Goal

Establish freshwater survival rates typical of Chinook salmon (~10% Egg→Smolt survival)

***Objective #3c*:** **(Population Growth – CRR= 4.03)**

By **year 24:**

a) the following minimum juvenile production successfully migrating past Caswell RST relative to WY type and spawner stock (previous fall escapement) will be exceeded:

Production at Caswell needed to Attain Abundance Target Assuming proportionate improvement in pre-Delta & Delta survival			
Unimpaired Year Type	**Dry**	**Medium**	**Wet**
Egg-CRST Survival →	13%	18.9%	25%
Spawning Stock			
2,000	650K	946.5K	1.25M
4,000	1.3M	1.893M	2.5M
6,000	1.95M	2.839M	3.75M
8,000	2.6M	3786M	5M
Basis: 1:1 spawner sex ratio; 5000 eggs/female; ~81% Caswell-Vernalis survival			

And

***b*)** Survival from Caswell-Mossdale ≥ 56.8% (pro-rata estimate of through-Delta survival

Abundance, Productivity, Growth Rate Goals on Other Tributaries

- We have data to estimate current production from tributaries

Table 4.2. Juvenile Chinook salmon emigrants at lower river monitoring locations per adult (from escapement estimates) in the San Joaquin River tributaries during years when monitoring occurred. The second listing of tributaries compares emigrants during years with data from all three tributaries, 2007-2009.

River	Years sampled	Average juvenile emigrants per adult	Range during years sampled
Stanislaus	1996 - 2009	166	8 – 571
Tuolumne	1995 - 2009	46	1 – 226
Merced	2007 - 2009	10	2 – 20
Comparison during years when estimates occurred in all tributaries.			
Stanislaus	2007 - 2009	30	8 – 49
Tuolumne	2007 - 2009	10	1 – 16
Merced	2007 - 2009	10	2 – 20

Source: *USDOI Testimony to the SWRCB 2011*

- Operating Assumptions:
  - A) Survival from Merced and Tuolumne to Mossdale should be similar to that for Stanislaus
  - B) Means fry/spawner should be *higher* on the tributaries because they will experience greater mortality in the San Joaquin

San Joaquin River Salmon
Bio-Criteria Summary

Type	Criteria	Part	What?	How Much?	By When?
Life History	1	a	Fry Timing	Same Range as Current	10 years
		b	Parr Timing	Begins 1wk Earlier	10 years
		c	Smolt Timing	Begins 7-10d Earlier	10 years
Life History	2	a	Fry Proportion	20% Wet yrs 20% Drier yrs	12 years
		b	Parr Proportion	20% Wet yrs 30% Drier yrs	12 years
		c	Smolt Proportion	10% Wet yrs 20% Drier yrs	12 years
FW Survival	3	a	Trib /Delta Survival	10% / 42.4%	9 years
		b	Trib /Delta Survival	12.1% / 51.4%	15 years
		c	Trib /Delta Survival	15.4% / 65.4%	24 years

Additional Actions
(Program of Implementation)

- **<u>Action A</u>:** Restore access to potential spawning & rearing habitats upstream of dams

- **<u>Action B</u>:** Hatchery reform to reduce or eliminate deleterious impacts of hatchery fish on natural spawning populations

- **<u>Action C:</u>** Restore/maintain historical range of timing for spawning migration, for both fall run and spring-running salmon

- **<u>Action D</u>:** Adult age structure and complete life history monitoring

The Bay Institute